An assessment of the impact of stocked walleye on stocked salmonids in the Milwaukee estuary

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EXECUTIVE SUMMARY

The Lower Milwaukee River and the estuary appear to have a limited nearshore fishery resource. Nearshore anglers are interested in developing a fishable walleye population in the Milwaukee River and the estuary. However, there is a concern that stocked walleye would feed heavily on stocked salmonids and could adversely affect the salmon fishery in Lake Michigan and its tributaries. The Lake Michigan Work Unit of the Wisconsin Department of Natural Resources agreed to conduct a study to evaluate the impact of stocked walleye on stocked chinook smolts in the Lower Milwaukee River. The Lakeshore Fisherman Sports Club and the Lakeridge Boat Club raised funding for a two year study for rearing, marking and subsequent stocking of the walleye fingerlings. About 17,000 extended growth walleye fingerlings appropriately marked to identify the year of stocking were stocked at a site immediately below the North Avenue Dam during the fall of 1995 and 1996. The chinook salmon smolts were stocked the following spring at the same location. In principle, it was agreed that if predation losses of stocked salmonids to the stocked walleye surpassed 5%, or if serious predation was obvious during early sampling, the second scheduled walleye stocking would not occur.

A pulsed D.C. electroshocker was used to capture fish. In 1996, the first sampling occurred one day after the chinook salmon smolt stocking, and the subsequent sampling occurred one week and three weeks after stocking the chinook salmon smolts for a total of three sampling events. A similar sampling schedule was followed in 1997 except that an additional prestocking sample was taken. The sampling goal was to examine 100 full walleye stomachs collected after dark when walleye are most actively feeding. The stomach samples were pumped out using a non-lethal SOLO Pressure Sprayer and contents were identified in the laboratory. Of the 134 stomachs examined in the spring of 1997, 43% had identifiable chinook salmon smolts. Approximately 4% of the stomachs contained identifiable non-salmonid fish. The proportion of walleye stomachs containing chinook salmon smolts ranged from 83% one day after chinook salmon stocking to 3% three weeks later. The number of chinook salmon smolts per stomach ranged from 1 to 3. It was estimated that the stocked walleye consumed 1,123 and 30,162 chinook salmon smolts prior to their migration from the Milwaukee Estuary, in 1996 and 1997, respectively. Our estimates are based on several unlikely assumptions about the survival and distribution of walleye, so actual predation on chinook salmon smolts was probably less.

Based on the results of this two year study, the WDNR is proposing several management alternatives to develop a Lower Milwaukee River and estuary nearshore fishery resource. These alternatives range from no walleye stocking to developing a self-sustaining walleye fishery in the estuary.

Part I - Walleye diet study

Introduction

This report summarizes a two year study to evaluate the effects of stocking fingerling walleye (*Stizostedion vitreum vitreum*) in the Lower Milwaukee River and the estuary on salmonid smolts stocked in the same area. A portion of our angling community is concerned that stocked walleye would feed heavily on stocked salmonids and could adversely affect the salmon fishery in Lake Michigan and its tributaries. At the same time, other anglers are interested in developing a fishable walleye population in the Milwaukee River and the estuary. Currently, the Lower Milwaukee River and the estuary support a minimal nearshore fishery resource.

As a general rule, small walleye feed on plankton and then switch to insects and fish. Walleye, at 3 inches long, are opportunistic predators and feed on larger items (Smith 1985). Reports from Michigan have indicated that walleye could be significant predators of trout stocked into Lake Huron tributaries (Johnson 1991, Johnson and Rakoczy 1995). Other literature indicates that walleye prey preferentially on rainbow smelt over salmonids (Jones et. al. 1994). In the current study, losses of recently stocked chinook salmon smolts to stocked walleye were assessed. It was agreed, at the outset, that if predation losses of stocked salmonids to the stocked walleye surpassed 5%, or if serious predation was obvious in the first year of study, the second scheduled walleye stocking would not occur.

The objective of this study is to evaluate the impact that walleye stocking has on stocked salmonid smolts, with an emphasis on chinook salmon (*Oncorhynchus tshawytscha)*, in the Lower Milwaukee River and its estuary. In addition, the Wisconsin Department of Natural Resources (WDNR) is trying to determine if walleye and salmonids can coexist in the area. Several management options are discussed at the end of this report. Detailed results of the first year's study are presented in Coffaro et. al. (1996).

Methods

The study design for the project included plans for stocking of 10,000 marked extended growth walleye fingerlings in the Lower Milwaukee River in each of two consecutive years. About 7,600 walleye fingerlings were stocked in October 1995 as part of the first year's stocking. For the second year of the study, approximately 10,000 extended growth walleye fingerlings (6 to 8 inches) were raised at the WDNR's hatchery in Spooner, WI and stocked in the Lower Milwaukee River in October 1996. The funding for rearing, marking and subsequent stocking of the fingerlings was provided by the Lakeshore Fisherman Sports Club and the Lakeridge Boat Club. The walleye were marked appropriately to identify the year of stocking (see Part II). The average length and weight of the fingerlings at the time of stocking were 7.3" and 58g, respectively.

An area immediately below the North Ave. dam on the Milwaukee River was chosen as a stocking site because of its fish habitat and accessibility. In 1996, in order to minimize stress from transportation and handling, walleye were marked at the hatchery and transported directly to the stocking site. Each walleye was marked with either a left pectoral clip (LP) or green elastomer mark (see Part II of this report). One-half (5,000) of the fish received a left pectoral clip and were stocked on October 2, 1996. The remainder were given a green elastomer mark and stocked on October 15, 1996. At the time of stocking a sample of 200 fish were measured to obtain an average length in order to calculate overall growth rate and as a quality control check of the marking techniques.

On May 7, 1997, 181,000 chinook salmon smolts (3.3" average length) were stocked in the same location where walleye were stocked the previous fall. Overall sampling design for the second year of the study remained the same as the previous year (Coffaro et al. 1996) except that an additional sampling was conducted which occurred one week prior to chinook salmon stocking. A pulsed D.C. electroshocker was used to capture fish. The stomach contents from stocked walleye were collected using a non-lethal pumping technique. Further samplings occurred one day, one week and three weeks after stocking the chinook salmon smolts for a total of four sampling events.

The sampling goal was to examine 100 full walleye stomachs collected after dark when walleye are most actively feeding. After each fish was measured, its mark recorded and the stomach pumped, a small hole was punched in the soft dorsal fin. This mark identified recaptured fish during subsequent samplings. The stomach samples were pumped out using a SOLO Pressure Sprayer (1 gal; 1/4 inch diameter tube), stored on ice and examined the following day. The contents were identified and tallied by taxonomic group to family, genus, or species.

Results

The results of the second year study are as follow. During the four nights of electroshocking (between 4/28/97 and 5/28/97), 134 walleye from the two consecutive years (1995 and 1996) of fall walleye stockings were captured. A stomach sample was collected from each fish. Ninety-five of the 134 stomach samples contained some food items (Table 1) and the remaining stomachs were empty. Some of the items were not identifiable. Recently eaten chinook salmon smolts were intact and easily identifiable. Of the 134 stomachs examined, 43% had identifiable chinook salmon smolts. Approximately 4% of the stomachs contained identifiable non-salmonid fish.

The timing and location of the sampling was adjusted in order to examine the greatest impact on the stocked salmonids. Chinook salmon smolts were stocked in the same general area of the walleye stocking the previous fall. The data revealed an interesting temporal pattern of change in the stomach contents of the walleye. We captured 17 walleye during the pre-chinook salmon stocking sampling (4/28/97) and none had any salmonids in their stomach. In the first round of sampling conducted after chinook smolts were stocked (5/8/97), the second night after the chinook stocking, 83% (38 out of 46) of the walleye captured contained chinook salmon smolts in their stomachs. The number of walleye with chinook salmon smolts dropped quickly in the subsequent samples (Table 1). One week post-stocking, only 49% (18 out of 37) of the walleye stomachs contained chinook salmon in their stomach. Further, only 3% (1 out of 34) of the stomachs examined three weeks post-stocking contained chinook salmon smolts.

The number of chinook salmon smolts per stomach varied from 1 to 3, the average being 1.3 chinook/walleye. While 75% of the walleye contained one smolt, only 3.5% had 3 smolts in the stomach. The average number of smolts per stomach decreased as time progressed. It was estimated that the stocked walleye consumed 1,123 and 30,162 chinook salmon smolts prior to their migration from the Milwaukee Estuary, in 1996 and 1997, respectively. Our estimates are based on several assumptions about the survival and distribution of walleye, so actual predation on chinook was probably less.

Discussion

The chinook salmon stocking created an artificial abundance of prey for the predator population. Given the opportunistic behavior of walleye, it was not surprising to find more walleye with chinook salmon smolts in their stomachs when there was an abundant supply of smolts in their immediate vicinity. We conducted a pre-stocking stomach analysis one week prior to chinook stocking to test the opportunistic feeding behavior of walleye. Of the 17 stomachs observed 9 had food items other than fish and 3 had parts of fish. Diet analysis of walleye from Oneida Lake, New York indicated that early June food items consisted of mostly chironomids, amphipods and other invertebrates (VanDeValk et al. 1994). As soon as there was an abundant supply of chinook salmon smolts in the Lower Milwaukee River the walleye switched to fish as a food item. Once the chinook salmon smolts dispersed from the area the walleye appeared to switch back to prey items other than smolts as seen by the increased number of invertebrates (chironomids and other insect larvae) in their stomachs (Table 1).

In September 1997 we set overnight gill nets to capture yellow perch in the outer harbor in Milwaukee as part of ongoing yellow perch research. During this time 28 walleye from the 1995 and 1996 stockings were captured in the gill nets, 22 of which were dissected in the laboratory to examine the stomach contents. Of the 22 stomachs, 12 had fish parts (of which four stomachs had identifiable fish including spottail shiner, stickleback, sculpin and alewife) and the remaining 10 stomachs were empty or contained digested matter. No salmonids appeared in these stomachs.

Yellow perch are a preferred prey for walleye. However, results from this study showed that no yellow perch were found in any walleye stomachs even though their range and habitat may overlap. There is a limited amount of vegetative cover and significant amount of breakwall and rip-rap in the outer harbor which yellow perch use as nursery areas. However, during years of good recruitment, young of the year yellow perch are also found in great abundance in more open shoreline areas. The best available information on walleye habitat preference in the estuary is from the 1990 and 1991 stocking of 5,500 age 1+ (mean length 8") walleye at six different sites, including three sites outside the harbor. In the years since these fish were stocked, recapture (both angler and assessment) information suggests that these walleye sought habitat very near shore, especially near rip-rapped areas, and in the river itself (which is not typical habitat for young of the year yellow perch). No walleye have been recaptured offshore in assessment gear, even in shallower, rocky substrate. The abundance of young of the year perch (pre-decline) in areas which walleye do not seem to occupy suggests that the overall impact of a limited walleye population on yellow perch recovery could be low. Yellow perch recruitment is a lakewide problem, with no apparent solution close at hand.

In the absence of walleye survivorship data in the lower river, it is difficult to quantify the total number of stocked chinook salmon smolts eaten by walleye alone. Furthermore, the small sample size was not adequate to allow us to estimate the population of walleye in the river. Four nights of electroshocking (average of 3-4 hrs/night) produced only 134 walleye. The number of chinook salmon smolts per stomach varied from 1 to 3, the average being 1.3 chinook/walleye. While 75% of the walleye contained one smolt, only 3.5% had 3 smolts in the stomach. The average number of smolts per stomach decreased as time progressed. The data show that the Lower Milwaukee River and estuary have a diverse fish community. Predatory northern pike (*Esox lucius*) and smallmouth bass (*Micropterus dolomieui*) occur in significant numbers and may have an impact on both stocked salmonids and walleye fingerlings. At the time of sampling, we observed many spring run steelhead (*Oncorhynchus mykiss*) which may also feed on smolts.

In both years of the study, walleye were stocked in October and chinook salmon were stocked the following May. The average size of walleye was greater in 1996 (7.3") compared to those stocked in 1995 (6.4"). The sampling time and sampling intervals were consistent in both years. The overall pattern of feeding behavior of walleye on chinook salmon smolts was consistent between the years. As the time progressed the proportion of walleye stomach samples with chinooks in their stomachs decreased, reaching almost zero within three weeks post stocking. There was a 34% drop from first sample to the second sample in 1997 (Table 1), and a 26% drop from sample one to sample two in 1996 (Table 2). Items other than chinook salmon smolts became more frequent at this time, especially in the spring of 1996 when 3-spine stickleback became abundant in the area. Other food items included insect larvae, worms and cyprinids. The average number of chinook per walleye also decreased from sample one to sample three in both years. In 1997, sample one was taken on the second night after chinook stocking, where as, in 1996, the first sample was taken on the third night. This may be one of the reasons why the average number of chinooks per walleye was greater in the 1997 sample (1.4 fish/walleye) than the 1996 sample (0.69 fish/walleye).

Based on the average number of chinook salmon smolts in stocked walleye stomachs for the three sampling periods in each year of the study, we estimated the total loss of chinook salmon smolts due to walleye predation. Our estimates represent the worst case scenario since the study was designed to examine the greatest impact (i.e. stocking chinook salmon smolts in the same location as walleye were stocked). The number of chinook salmon smolts consumed are also based on several unlikely assumptions: 1) All surviving walleyes were in the area of chinook salmon stocking and consume chinook salmon at the same rate and 2) These walleyes remain in this area for the entire time that the chinook salmon smolts are present. It was estimated that the stocked walleye consumed 1,123 and 30,162 chinook salmon smolts prior to their migration from the Milwaukee Estuary, in 1996 and 1997, respectively. Our estimates are based on several assumptions about the survival and distribution of walleye, so actual predation on chinook was probably less. It is clear from the study that the stocked walleye do eat chinook salmon smolts. However, we have many unanswered questions that preclude obtaining a realistic estimate of the losses. For example, What percent of walleye survive the winter? How are stocked walleye distributed in the estuary? How might stocking chinooks in different places help reduce mortality?

Proposed Management Alternatives

In concept, WDNR Southeast Region and Bureau of Fisheries Management and Habitat Protection staff are in favor of the restoration of a self-sustaining population of walleye in the Lower Milwaukee River and its estuary with a goal of 2 adult walleye per acre. With the decline of the yellow perch population, the nearshore fishery has been severely impacted, especially for those without access or means to utilize the healthy trout and salmon fishery.

The preceding report has outlined the results of a two year study on the impact walleye predation may have on stocked salmonids. Small sample sizes, one year class of walleye which apparently experienced poor survivorship, and limited historical data on walleye population dynamics in this estuary make predicting the outcome of walleye restoration difficult. Nevertheless, preliminary results of the work conducted thus far suggest several options.

OPTION 1: Discontinue walleye stocking

OPTION 2: Postpone walleye stocking for one additional year (i.e. no stocking in 1998), continue to sample the existing population according to the established design while adjusting chinook salmon stocking sites.

OPTION 3: Annually stock 10,000 extended growth (6-8") Great Lakes strain walleye fingerlings for 7 years (1998-2004) at the current North Avenue Dam location while changing chinook salmon stocking sites to avoid concentrating them in areas of stocked walleye.

OPTION 4: In 1998 stock 10,000 extended growth (6-8") Great Lakes strain walleye fingerlings and then annually stock 30,000 Great Lakes strain walleye fingerlings (2-4") for 6 years (1999-2004) at the current North Avenue Dam location while changing chinook salmon stocking sites to avoid concentrating them in areas of stocked walleyes.

OPTION 5: In 1998 stock 10,000 extended growth (6-8") Great Lakes strain walleye fingerlings and then annually stock 50,000 Great Lakes strain walleye fingerlings (2-4") for 6 years (1999-2004) at various locations in the Milwaukee River while changing chinook salmon stocking sites to avoid concentrating them in areas of stocked walleyes.

The preceding options are not necessarily all-inclusive, and are not in any prioritized order. Each option is further discussed below in more detail and with possible implications.

OPTION 1: Discontinue walleye stocking

Walleye extended growth fingerlings have been stocked in the Milwaukee River in 1995 and 1996 at about 17,000 fish (both years combined). No fish were stocked in 1997 and under this option no further stocking of walleyes will occur.

Implications:

a. Potential negative impacts of walleye on salmonid smolts and yellow perch would be eliminated.

b. No further rearing and stocking costs for extended growth walleye fingerlings.

c. The nearshore walleye fishery would continue to be minimal.

d. Restoration of a reproducing walleye population, a native species, would not be accomplished.

OPTION 2: Postpone walleye stocking for one additional year (i.e. no stocking in 1998), continue to sample the existing population to assess the impact according to the established design while adjusting chinook salmon stocking sites.

About 17,000 (both years combined) extended walleye growth fingerlings have been stocked in the Milwaukee River in 1995 and 1996. No fish were stocked in 1997 and under this option no walleyes would be stocked in 1998. During 1998, walleye diet information would be collected using the same methods as previous years with several exceptions: chinook salmon would be stocked in May at one or more downstream sites (i.e. McKinley Marina, Pieces of Eight, Summerfest, South Shore) and only 2 and 3 year old walleyes would be collected for diet information since no extended growth walleyes were stocked the previous fall.

Implications:

a. Due to normal annual mortality, the sample sizes could be very small making comparisons among the years difficult. In addition, sampling of older and larger walleye (age 2 and 3) and comparing the data to previous years of sampling yearling walleye (age 1) would not be a valid comparison.

b. Because chinook salmon stocking sites would be altered from "worst case scenario" (i.e. stocking all chinook salmon smolts in May at the same location as walleye were stocked the previous fall) to several downstream sites and no walleyes were stocked in fall 1998, direct comparisons to diet data already collected would be difficult.

c. Restoration of a reproducing walleye population, a native species, would not be accomplished.

OPTION 3: Annually stock 10,000 extended growth (6-8") Great Lakes strain walleye fingerlings for 7 years (1998-2004) at the current North Avenue Dam location while changing chinook salmon stocking sites to avoid concentrating them in areas of stocked walleye. After the stocking period, measure the performance of the stocked walleyes by using creel effort and harvest statistics, walleye annual surveys and walleye diet surveys.

Under this option 10,000 extended growth walleyes would be stocked in 1998 through 2004. During 1998 and 1999, walleye diet information would be collected using the same methods as previous years with several exceptions: chinook salmon would be stocked in May at one or more downstream sites (i.e. McKinley Marina, Pieces of Eight, Summerfest, South Shore) and only 2 and 3 year old walleyes would be collected for diet information in 1998 since no extended growth walleyes were stocked in fall 1997. However, in 1999, diet information would be collected from yearling and older walleye following the same procedures as previous years.

By stocking 10,000 extended growth walleyes from 1998-2004 the goal of 2 adult walleye per acre in the Milwaukee Estuary is not met (Appendix A). Appendix 1 shows the proposed stocking rates (Table 1A), the mortality rates by age (Table 2A) and the final population levels in summer from 1996 to 2010 (Table 3A). The adult mature walleye population peaks in 2007 at 1,240 walleyes but is only 0.95 walleye/acre, much lower than needed for producing a self-sustaining walleye population. Under this option, walleye restoration will not be achieved because of the lower stocking rates. However, a fishable walleye population sustained only through stocking may be achieved.

Implications:

a. Additional costs associated with raising walleye fingerlings to 6-8" will be high, about $1.00 per fish. This money will have to be budgeted for each year.

b. Larger fingerlings are more readily marked (e.g. finclips) making diet studies and future assessments easier and more accurate, and survivorship is higher than with regular (2") fingerlings.

c. Based on current estimates of mortality rates and populations levels (Appendix A), the maximum number of adult walleye in the population would be 1,240 only 0.95 fish/acre in 2007, well below the 2.0 fish/acre needed for restoration of walleye.

d. In producing a walleye population peaking at about 0.95 walleye/acre in 2007, we could be producing a fishable population of walleye for the near shore area.

OPTION 4: In 1998 stock 10,000 extended growth (6-8") Great Lakes strain walleye fingerlings and then annually stock 30,000 Great Lakes strain walleye fingerlings (2-4") for 6 years (1999-2004) at the current North Avenue Dam location while changing chinook salmon stocking sites to avoid concentrating them in areas of stocked walleyes. After the stocking period, measure the performance of the stocked walleyes by using creel effort and harvest statistics, walleye annual surveys and walleye diet surveys.

Under this option 10,000 extended growth walleyes (6-8") would be stocked in 1998 and 30,000 fingerlings (2-4") would be stocked from 1999 through 2004. During 1998 and 1999, walleye diet information would be collected using the same methods as previous years with two exceptions: chinook salmon would be stocked in May at one or more downstream sites (i.e. McKinley Marina, Pieces of Eight, Summerfest, South Shore) and only 2 and 3 year old walleyes would be collected for diet information in 1998 since no extended growth walleyes were stocked in fall 1997. Because we will stock one more year of extended growth fingerlings in fall 1998, diet information would be collected from yearling and older walleye in 1999 following the same procedures as previous years.

By stocking 10,000 extended growth walleyes in 1998 and 30,000 fingerlings in 1999-2004 the goal of 2 adult walleye per acre in the Milwaukee Estuary is not met (Appendix B). Appendix 2 shows the proposed stocking rates (Table 1B), the mortality rates by age (Table 2B) and the final population levels in summer from 1996 to 2010 (Table 3B). The adult mature walleye population peaks in 2007 at 1,486 walleyes but is only 1.14 walleye/acre, much lower than needed for producing a self-sustaining walleye population. Under this option, walleye restoration will not be achieved because of the lower stocking rates. However, a fishable walleye population sustained only through stocking may be achieved.

Implications:

a. No additional costs for producing fingerlings (2-4") will occur. Money for the 1998 extended growth fingerlings has already been accounted for.

b. Based on current estimates of mortality rates and populations levels (Appendix B), the maximum number of adult walleye in the population would be 1,486 only 1.14 fish/acre in 2007, well below the 2.0 fish/acre needed to achieve a self-sustaining walleye population.

c. In producing a walleye population peaking at about 1.14 walleye/acre in 2007, we could be developing a fishable population of walleye for the near shore area.

OPTION 5: In 1998 stock 10,000 extended growth (6-8") Great Lakes strain walleye fingerlings and then annually stock 50,000 Great Lakes strain walleye fingerlings (2-4") for 6 years (1999-2004) at various locations in the Milwaukee River while changing chinook salmon stocking sites to avoid concentrating them in areas of stocked walleyes. After the stocking period, measure the performance of the stocked walleyes by using creel effort and harvest statistics, walleye annual surveys and walleye diet surveys.

Under this option 10,000 extended growth walleyes (6-8") would be stocked in 1998 and 50,000 fingerlings (2-4") would be stocked from 1999 through 2004. During 1998 and 1999, walleye diet information would be collected using the same methods as previous years with two exceptions: chinook salmon would be stocked in May at one or more downstream sites (i.e. McKinley Marina, Pieces of Eight, Summerfest, South Shore) and only 2 and 3 year old walleyes would be collected for diet information in 1998 since no extended growth walleyes were stocked in fall 1997. Because we will stock one more year of extended growth fingerlings in fall 1998, diet information would be collected from yearling and older walleye in 1999 following the same procedures as previous years.

By stocking 10,000 extended growth walleyes in 1998 and 50,000 fingerlings in 1999-2004 the goal of 2 adult walleye per acre in the Milwaukee Estuary will be met (Appendix C). Appendix 3 shows the proposed stocking rates (Table 1C), the mortality rates by age (Table 2C) and the final population levels in summer from 1996 to 2010 (Table 3C). The adult mature walleye population peaks in 2007 at 2,471 walleyes and will be 1.90 walleye/acre, high enough to produce a self-sustaining walleye population. Under this option, walleye restoration may be achieved because of the higher stocking rates.

Implications:

a. No additional costs for producing fingerlings (2-4") will occur. Money for the 1998 extended growth fingerlings has already been accounted for.

b. Based on current estimates of mortality rates and populations levels (Appendix C), the maximum number of adult walleye in the population would be 2,471 or 1.90 fish/acre in 2007, close to the 2.0 fish/acre goal needed to achieve a self-sustaining walleye population.

c. A self-sustaining walleye population may impact our ability to continue to stock chinook salmon smolts in the Milwaukee area.

Approaches to mitigate loss of chinook salmon smolts from predation

1. Stocking chinook salmon smolts at more than one site.

Under this scenario we will spread out chinook salmon smolt stocking at several downstream sites away from the walleye fingerling stocking site. Potential sites would include, but are not limited to, McKinley Marina, Pieces of Eight, Summerfest and South Shore. This approach is expected to reduce the loss of smolts due to predation since they would not be concentrated in the same area where walleye are stocked.

2. Adjust for the loss of chinook salmon smolts.

Currently, the Southeast Region of the Wisconsin Department of Natural Resources is allotted 780,000 chinook salmon smolts to stock in its waters. Approximately, 156,000 chinook salmon smolts are stocked in five areas including Kenosha, Racine, Milwaukee, Port Washington and Sheboygan. Under this approach, a percentage of chinook salmon smolts would be taken from Kenosha, Racine, Port Washington and Sheboygan and stocked in Milwaukee to compensate for the number of chinook salmon smolts eaten by stocked walleyes proposed in options 3-5. The reallocation would mean that all areas would receive the same amount of chinook salmon smolts but at a reduced rate from current stocking levels.

3. Develop alternate procedures to increase survival rate of stocked chinook salmon smolts.

Using holding pens for salmonid smolts has been successfully practiced elsewhere in the Great Lakes. Michigan DNR has had a great deal of success using holding pens for chinook salmon smolts. Holding smolts in a pen for 3 to 4 weeks prior to release gives them a chance to acclimate to a new environment and imprint to the stocking site, which could increase the survival and return rates. The use of pens in the Milwaukee estuary could be considered for future chinook salmon stocking as a way to compensate for the losses due to walleye predation.

Part II - Elastomer marking

Introduction

Evidence from trout and salmon studies on the west coast suggest that alternative marking methods may result in increased survivorship when compared to finclipping. Since these walleye needed to be marked as part of the diet study, it was decided to take advantage of an opportunity to test an alternative marking method in Lake Michigan waters. Red elastomer was used in 1995 and green elastomer in 1996.

Methods

This method consisted of an externally visible injected plastic implant known as elastomer. The technique involved injecting a small quantity of liquid fluorescent elastomer just under the skin. The injection is made using an air-driven system utilizing a small gauge needle. The material is allowed to harden ("cure") for two days. Handling the fish is avoided for 10-14 days after marking. This allows the needle wound to heal to preclude forcing cured material out of the wound. The material cures into a flexible mark which is easily visible to the naked eye. As the fish grows, the mark remains intact and is visible with either the naked eye or by shining ultra-violet light over the fish. The material is available in four colors, and is best implanted into any clear or light-colored tissue on the fish. The walleye were marked with elastomer on the underside of the jaw, along the white tissue below the jawbone.

Both years, we chose to mark approximately half of the total number of fish stocked with elastomer, and to finclip the other half (1995, right pectoral; 1996, left pectoral). We would then be able to follow the fish in subsequent years (during routine sampling) to compare the performance of elastomer marked fish versus finclipped fish.

Results and Discussion

The marking protocol for 1996 was identical to the previous years. Tables 3-5 summarize the stocking and recapture information relative to each marking technique for both year classes of walleye. As was the case for the 1995 stocking, a small percentage of elastomer tags were lost (shed) by some fish. Subsampling at time of stocking revealed that of all fish marked with elastomer in 1996, 3% shed their tags prior to stocking (1.5% of the total number of fish stocked). The percentages for shed marks are in relation to the total number of fish stocked or recaptured (Table 3).

As in 1996, the 1997 data indicate that there is no difference in survivorship over the first winter between the elastomer marked walleye and finclipped walleye. However, as shown in Table 4, the 1997 recapture rate for the first group of walleye stocked (1995) was very low for both elastomer marked and finclipped fish, so no conclusions can be drawn at this point regarding long-term differential survival. It is possible overall survival of this year class was poor. Evaluation of the elastomer marking technique will continue as these year classes are followed each sampling season.

Acknowledgments

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Table 1. Results of walleye diet study in Lower Milwaukee River and estuary in 1997 showing the numbers of walleye collected; walleye with full stomachs; the number of stomachs containing chinook salmon smolts; and the numbers containing other fish, fish parts or other prey items. (This table includes the walleye recaptured from 1995 and 1996 stockings)

Sampling date	# of walleye sampled	# of walleye with full stomach	# of stomachs containing chinook salmon[a]	# of stomachs with non-salmonids	# of stomachs with unidentified fish parts	# of stomachs with other prey items
4/28/97	17[b]	10	0	1	2	9
5/8/97	46	43	38 (1.4)	2	9	19
5/15/97	37	30	18 (0.63)	0	11	7
5/28/97	34	12	1 (0.08)	1	5	6
TOTAL	134	95	57	4	27	41

[a] numbers in the parentheses indicate average number of chinook salmon per stomach for each sampling period, *only for those walleye having full stomachs.*
[b] walleye sampled prior to stocking chinook smolts

Table 2. Results of walleye diet study in Milwaukee River Harbor in 1996 showing the numbers of walleye collected; walleye with full stomachs; the number of stomachs containing chinook salmon smolts; and the numbers containing other fish, fish parts or other prey items.

Sampling date	# of walleye sampled	# of walleye with full stomach	# of stomachs containing chinook salmon[a]	# of stomachs with non-salmonids	# of stomachs with unidentified fish parts	# of stomachs with other prey items
5/8/96	36	29	14 (0.69)	5	13	8
5/15/96	85	30	11 (0.37)	7	12	8
5/29/96	36	15	0 (0)	8	2	9
TOTAL	157	74	25	20	27	25

[a] numbers in the parentheses indicate average number of chinook salmon per stomach for each sampling period, *only for those walleye having full stomachs.*

Table 3. Walleye stocking summary

	Stocked	Finclipped[&]	Elastomer[@]	Shed Elastomer
1995	7,626	3,338 (43.8%)	4,181 (54.8%)	107 (1.4%)
1996	9,972	4,999 (50.1%)	4,824 (48.4%)	149 (1.5%)
Totals	17,598	8,337 (47.4%)	9,005 (51.2%)	256 (1.4%)

& 1995 clip: right pectoral, elastomer color: red

@ 1996 clip: left pectoral, elastomer color: green

Table 4. Marked walleye recapture summary, numbers of fish recaptured.

	Finclipped	Elastomer	Shed Elastomer	Total recaptured
1996	66 (RP)	84 (red)	3	153
1997	5 - RP 75 - LP 80 total	3 - red 76 - green 79 total	3	162
Total	146	163	6	315

Table 5. Comparisons of fish stocked, each marking technique, with recapture rates.

	Finclipped	Elastomer	Shed Elastomer
1995 stocked	43.8%	54.8%	1.4%
1996 recaptured	43.1% (66)	54.9% (84)	2.0% (3)
1996 stocked	50.1%	48.4%	1.5%
1997 recaptured*	48.7% (75)	49.4% (76)	1.9% (3)
Total stocked	47.4%	51.2%	1.4%
Total recaptured**	46.4%	51.7%	1.9%

* for 1996 stocked fish only (LP & green elastomer)

** both year classes combined

APPENDIX A

Walleye Stocking/Population Model - OPTION 3

TABLE 1A. Walleye Stocking Rates by year and type of walleye

Year	Number	Type
1995	7,626	EXT
1996	9,972	EXT
1997	0	
1998	10,000	EXT
1999	10,000	EXT
2000	10,000	EXT
2001	10,000	EXT
2002	10,000	EXT
2003	10,000	EXT
2004	10,000	EXT

EXT = Extended growth fingerlings 6-8"
FING = Fingerlings 2-4"

TABLE 2A. Mortality Rates by age and year class

Year Class	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9
1995	0.95	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1996	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1997	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1999	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2000	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2001	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2002	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2003	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2004	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

TABLE 3A. Total and adult population levels and adult walleye per acre by year

Year	Final Population Levels Summer	Adult mature population	Adult Walleye Per Acre (1,300 acres)
1996	381	0	0.00
1997	2,684	0	0.00
1998	1,342	95	0.07
1999	3,171	671	0.52
2000	4,085	335	0.26
2001	4,543	793	0.61
2002	4,771	1,021	0.79
2003	4,886	1,136	0.87
2004	4,943	1,193	0.92
2005	4,971	1,221	0.94
2006	2,480	1,230	0.95
2007	1,240	1,240	0.95
2008	615	615	0.47
2009	303	303	0.23
2010	146	146	0.11

APPENDIX B

Walleye Stocking/Population Model - OPTION 4

TABLE 1B.Walleye Stocking Rates by year and type of walleye

Year	Number	Type
1995	7,626	EXT
1996	9,972	EXT
1997	0	
1998	10,000	EXT
1999	30,000	FING
2000	30,000	FING
2001	30,000	FING
2002	30,000	FING
2003	30,000	FING
2004	30,000	FING

EXT = Extended growth fingerlings 6-8"
FING = Fingerlings 2-4"

TABLE 2B.Mortality Rates by age and year class

Year Class	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9
1995	0.95	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1996	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1997	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1999	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2000	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2001	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2002	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2003	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2004	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

TABLE 3B.Total and adult population levels and adult walleye per acre by year

Year	Final Population Levels Summer	Adult mature population	Adult Walleye Per Acre (1,300 acres)
1996	381	0	0.00
1997	2,684	0	0.00
1998	1,342	95	0.07
1999	3,171	671	0.52
2000	4,585	335	0.26
2001	5,293	793	0.61
2002	5,646	1,146	0.88
2003	5,823	1,323	1.02
2004	5,912	1,412	1.09
2005	5,955	1,455	1.12
2006	2,973	1,473	1.13
2007	1,486	1,486	1.14
2008	738	738	0.57
2009	363	363	0.28
2010	176	176	0.14

APPENDIX C

Walleye Stocking/Population Model - OPTION 5

TABLE 1C.Walleye Stocking Rates by year and type of walleye

Year	Number	Type
1995	7,626	EXT
1996	9,972	EXT
1997	0	
1998	10,000	EXT
1999	50,000	FING
2000	50,000	FING
2001	50,000	FING
2002	50,000	FING
2003	50,000	FING
2004	50,000	FING

EXT = Extended growth fingerlings 6-8"
FING = Fingerlings 2-4"

TABLE 2C.Mortality Rates by age and year class

Year Class	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9
1995	0.95	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1996	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1997	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1999	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2000	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2001	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2002	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2003	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2004	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

TABLE 3C.Total and adult population levels and adult walleye per acre by year

Year	Final Population Levels Summer	Adult mature population	Adult Walleye Per Acre (1,300 acres)
1996	381	0	0.00
1997	2,684	0	0.00
1998	1,342	95	0.07
1999	3,171	671	0.52
2000	6,585	335	0.26
2001	8,293	793	0.61
2002	9,146	1,646	1.27
2003	9,573	2,073	1.59
2004	9,787	2,287	1.76
2005	9,893	2,393	1.84
2006	4,941	2,441	1.88
2007	2,471	2,471	1.90
2008	1,230	1,230	0.95
2009	605	605	0.47
2010	293	293	0.23

Literature cited

Coffaro, M., J. Thompson and P. S. Hirethota. 1996. Preliminary report on the impact of stocked salmonids and an evaluation of the elastomer tagging technique, Wisconsin Department of Natural Resources, Lake Michigan Work Unit. 6pp.

Johnson, J. E. 1991. Investigations into causes of, and solutions for, recent declines in survival of trout stocked in Lake Huron. Michigan Department of Natural Resources, Study performance report. Study 469, project F-53-R-7, 10 pp.

Johnson, J. E. and G. Rakoczy. 1995. Investigations into causes of, and solutions for, recent declines in survival of trout stocked in Lake Huron. Michigan Department of Natural Resources, Study performance report. Study 469, project F-53-R-11, 16 pp.

Jones, M. S., J. P. Goettl, Jr., and S. A. Flickinger. 1994. Changes in walleye food habits and growth following a rainbow smelt introduction. North American Journal of Fisheries Management 14:409-414.

Smith, C. L. 1985. The Inland Fishes of New York State. New York Department of Environmental Conservation, Albany, NY. 522 pp.

VanDeValk, A. J., L. G. Rudstam and J. L. Forney. 1994. Walleye stock assessment and population projections for Oneida Lake, 1994-97. Cornell University Biological Field Station, Bridgport, New York.

Wolfert, D. R. and M. T. Bur. 1992. Selection of prey by walleyes in the Ohio waters of the central basin of Lake Erie, 1985-1987. U.S. Fish and Wildlife Service Resource Publication 182. 14pp.